Mapping and Interpretation of Buried Channels in The Vicinity of Clifton Gorge, Ohio

Senior Thesis

by

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The topographic map, of Clifton Ohio with buried channels, was missing from the back of the original senior thesis by Colin Michael Hartnett.

Patti Dittoe
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Introduction and Purpose

As streams and rivers form over time, they tend to cut outward and downward into their banks and beds. These processes, known as channel widening and downcutting, are initiated by various events which affect the budget of the stream or river. Among these events are increases in water supply, lowering of local or regional base level, damming or rerouting of drainage by glacial ice or orogenic activity, increases in sediment load of the river, and regional uplift or isostatic rebound.

The agents of widening and downcutting in a stream are the flowing water and the sediment load carried by the water. The flowing water provides the hydraulic force that removes loose material. Sediments powered by the water in which they are carried, abrade the stream channel. Additionally, flowing water is responsible for the phenomenon of cavitation which enables even a sediment free stream to cut into the bedrock. Finally, flowing water may affect the channel by solution activity.

The result of widening and especially downcutting, is often a channel in bedrock over which the river runs.

The river may change course, dry up, or become filled with sediment from various sources, but the channel, cut into the bedrock, remains as an indicator of the deepest point reached by the downcutting stream.

An abandoned channel later may be used by a new river, or, if buried, act as a ground water aquifer. Such a course of events has occurred through Pleistocene and recent times in the area of Clifton Gorge, located in Greene County, Ohio near the Clark-Greene county line, (figure 1).

The purposes of this study are two-fold. The first is to locate any buried channels north of the gorge area. This type of information is often useful in the location of ground water sources for private, commercial, and community use. According to Norris in The Water Resources of Greene County, Ohio, "The best ground water areas in the county are in the parts of buried valleys where permeable outwash deposits of gravel and sand are traversed by the large streams.", (1950, P. 36). Therefore, locating buried valleys is a primary step in finding good sources of ground water.

The second purpose of this study is to determine how and when these channels were formed and to understand the

Map of Ohio, showing location of the area included in this report.

REDRAWN FROM GREENE COUNTY WATER RESOURCES REPORT, ODNR.

FIGURE 1

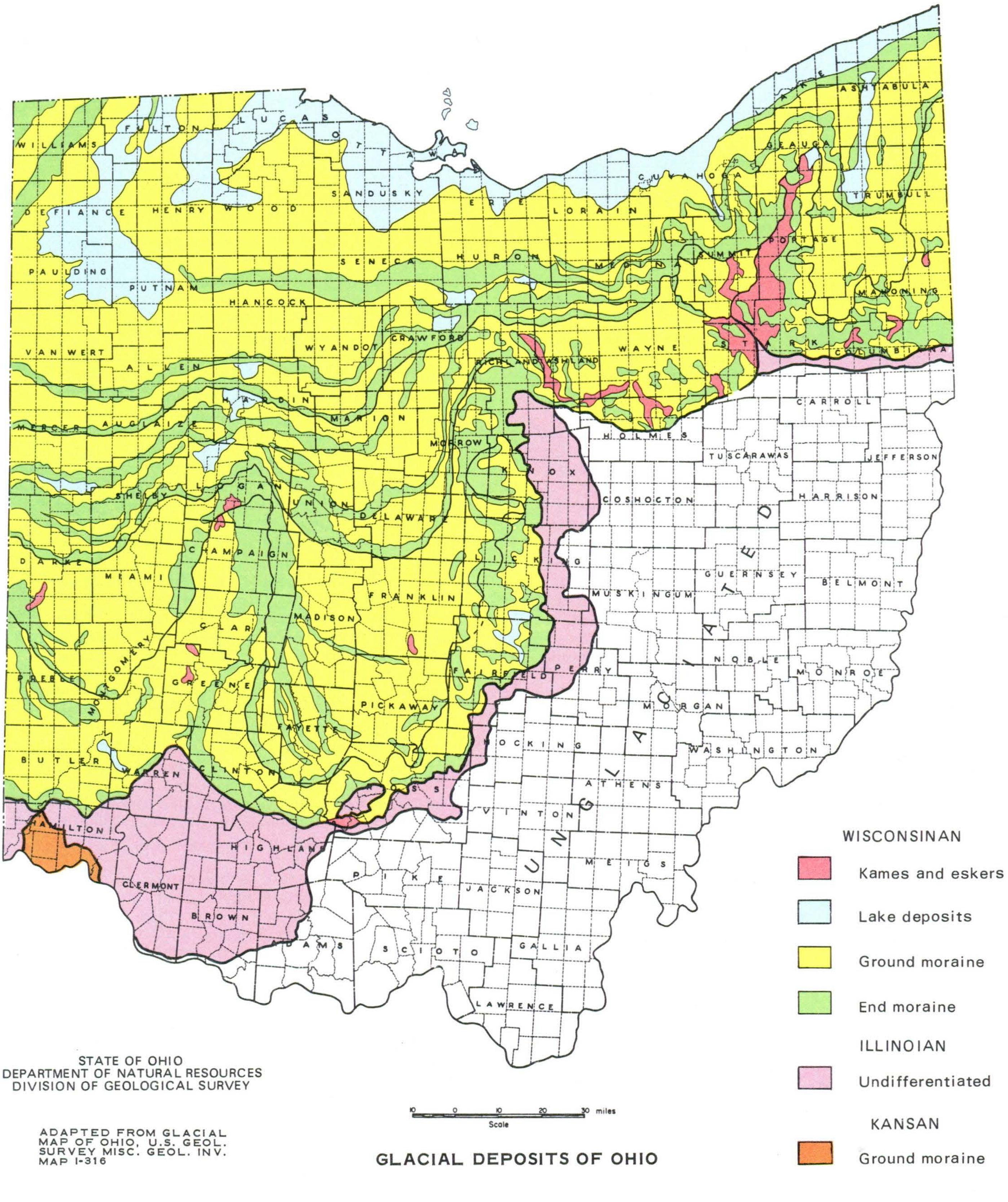
geologic history of the region. The results of this study may then be correlated with studies of ancient drainage systems in adjacent areas. The drainage changes that have occurred in Ohio over the last million years have been the subject of study by scientists of various disciplines, however, many questions remain.

Description of Area

Clifton Gorge is located in John Bryan Sate Park which is to the west of the town of Clifton and to the east of Yellow Springs. The Little Miami River enters the gorge at Clifton as it flows southwest, (Map in pocket). The river's gradient increases markedly, but only temporarily, at this point. A prominant chasm, known as Yellow Springs Gorge, extends northwest from Clifton Gorge to Yellow Springs. While Yellow Springs Gorge is as deep as Clifton Gorge, (46 meters), there is only a small stream flowing southeast through it. The maximum surface and bedrock surface relief in the area is only 60 meters, (Map in pocket, figures A-F). Therefore, these two gorges are very prominant surface features of this area.

North of John Bryan State Park ~~are~~ is a series of outwash plains from the retreat of the Wisconsinan glaciation, (figure 2)(Brown, 1948, P. 66). To the south, east, and west, the land rises into a complex series of end and ground moraines from various glaciations. (Brown, 1948, P. 66).

The age of the bedrock in the area is Niagaran (Silurian Period), (Norris, Cross, Goldthwait, 1950, P. 19). Both the Massie Clay Shale and overlying Euphemia Dolomite, which forms the resistant rims and walls of the gorge, outcrop in the gorge and underlie this area, (Norris, Cross, Goldthwait, 1950, P. 19). Niagaran bedrock in Clark and Greene counties is regarded as a good source of ground water. Therefore many water wells have been drilled into the bedrock in the two counties.



STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY

ADAPTED FROM GLACIAL MAP OF OHIO, U.S. GEOL. SURVEY MISC. GEOL. INV. MAP I-316

GLACIAL DEPOSITS OF OHIO

FIGURE 2

GLACIAL MAP OF OHIO

Although perhaps difficult to imagine, Ohio at one time had almost three-quarters of its surface area covered by vast sheets of ice perhaps as much as one mile thick. Ohio has, in fact, been partially covered by great ice sheets at least three and possibly four times in the recent (within the last few million years) geologic past.

Evidence in the geologic record suggests that periods of extensive glaciation extend far into the world's geologic past. The most recent period of glaciation and one which is evident in Ohio is known geologically as the Pleistocene Epoch (11,000 to 2,000,000 years before present). This period of geologic history is also commonly referred to as the Ice Age, although, as stated previously, there were certainly other "ice ages" in the past.

During the Pleistocene, four major ice advances are known to have occurred on the North American continent. These advances, named Nebraskan, Kansan, Illinoian, and Wisconsinan, from oldest to youngest, came from northern Canada and were the result of climatic conditions which allowed massive build-ups of ice. Because of their great thickness these ice masses flowed under their own weight and ultimately moved south as far as northern Kentucky, crossing the Ohio River in the Cincinnati area.

There is no direct evidence that the first ice sheet, the Nebraskan, occupied Ohio. In the Cincinnati region there is one small area of glacial deposits (shown in brown on map) which is considered by some geologists to be of Kansan age. The Illinoian ice sheet (lavender area on map) covered the largest area of Ohio, and its deposits are found from Cincinnati to Youngstown. However, because each major advance covered the deposits left by the previous ice sheets, the features shown on the glacial map are largely the result of the last or Wisconsinan-age glaciers.

The material left by the ice sheets consists of mixtures of clay, sand, gravel, and boulders in various types of deposits of different modes of origin. Rock debris carried along by a glacier was deposited in two principal fashions, either directly by the ice or by meltwater from the glacier. Some material reaching the ice front was carried off by streams of meltwater to form outwash deposits. These deposits normally consist of sand and gravel. Sand and gravel in forms called kames and eskers (shown in red) were deposited by water on and under the surface of the glacier itself and are recognized by characteristic shapes and composition. The distinctive characteristic of glacial debris that has been moved by water is that it was sorted by the water which carried it off. The larger boulder-size particles were left behind while the smaller clay-size particles were carried far away, leaving the intermediate gravel- and sand-size materials along the stream courses.

Boulder- to clay-size material deposited directly from the ice was not sorted. Some of the debris was deposited as ridges parallel to the edge of the glacier itself, forming a terminal or end moraine (shown on map in dark green), which marks the position of the retreating ice when it paused for a period of time, possibly a few hundred years. When the entire ice sheet receded because of melting, much of the ground-up rock material still held in the ice was deposited on the surface as ground moraine (light green on map). The term glacial drift is commonly used to refer to any material deposited at or behind the terminal edge of a glacier. Because the ice which invaded Ohio came from Canada, it carried in many rock types not found in Ohio. Boulders of these foreign rock types are called erratics. Rock collecting in areas covered with glacial drift or in glacial outwash deposits may yield granite, gneiss, trace quantities of gold, and, very rarely, diamonds. The bulk of the rocks found in glacial deposits, however, will be those types native to Ohio.

Many glacial lakes were formed during the time ice covered Ohio. Lake deposits (shown in blue) are primarily very fine-grained clay- and silt-size sediments. The most extensive area of lake deposits is in northern Ohio bordering Lake Erie. These deposits represent early stages in the development of Lake Erie as it is presently known.

Certain deposits left behind by the ice are of economic importance, particularly sand and gravel, clay, and peat. Sand and gravel, which has been sorted by meltwater, is generally found as kames or eskers or as outwash deposits along major drainageways. Sand and gravel is vital to Ohio's construction industry and deposits are abundant within the state.

Glacial clay is used in cement and for common clay products (particularly field tile). The minor quantities of peat produced in the state are used mainly for mulch and soil conditioning.

Method of Study

Cross sections in this report were constructed from well logs for Clark and Greene Counties on file at The Ohio Department of Natural Resources Division of Water. In most cases the individual wells are located on a map accompanying the data. However, in some cases it was necessary to locate the well through a written description on the log sheet.

The character of the material drilled through, and the depths at which these materials were encountered are recorded on the well log sheet. For the purpose of this study, wells were classified as those into the bedrock and those which do not reach the bedrock.

The first classification of wells gives an accurate measure of depth to the bedrock at a given location. Profiles in such areas are represented by a solid line. The second classification tells only that the bedrock obviously lies somewhere below the maximum depth of the well. However, these pieces of negative information are useful in constructing cross sections in that they tell where the bedrock is not. Profiles in such areas are represented by a dashed line. Dashed lines with question marks indicate areas of insufficient data.

Once well locations and depths were recorded, a series of cross sections ~~were~~ was constructed employing a strategy which would reveal major buried channels coursing roughly north of Clifton and Yellow Springs Gorges (Figures A-E). The assumption was made, on the basis of work by Stout and later work by Norris (Figures 3, 4, 5), that to the south of the gorges, any Teays channel gradients would have been altered by Deep Stage downcutting. These channels would, therefore, be unrecognizable from Deep Stage and more recent bedrock channels. Evidence supporting this may be seen in the Deep Stage System map (Figure 5) by Norris (1950) which appears to indicate southerly drainage from the gorge area.

In order to use the maximum amount of information, well depths and their elevations, were projected into the lines of section. Therefore, cross sections in this report only approximate the surface and bedrock surface along the line of section. However, wells projected into the line of section were generally located within one half

FIGURE 3

TEAYS DRAINAGE SYSTEM

REDRAWN AND ENLARGED (STOUT, VER STEEG, LAMB) 1943

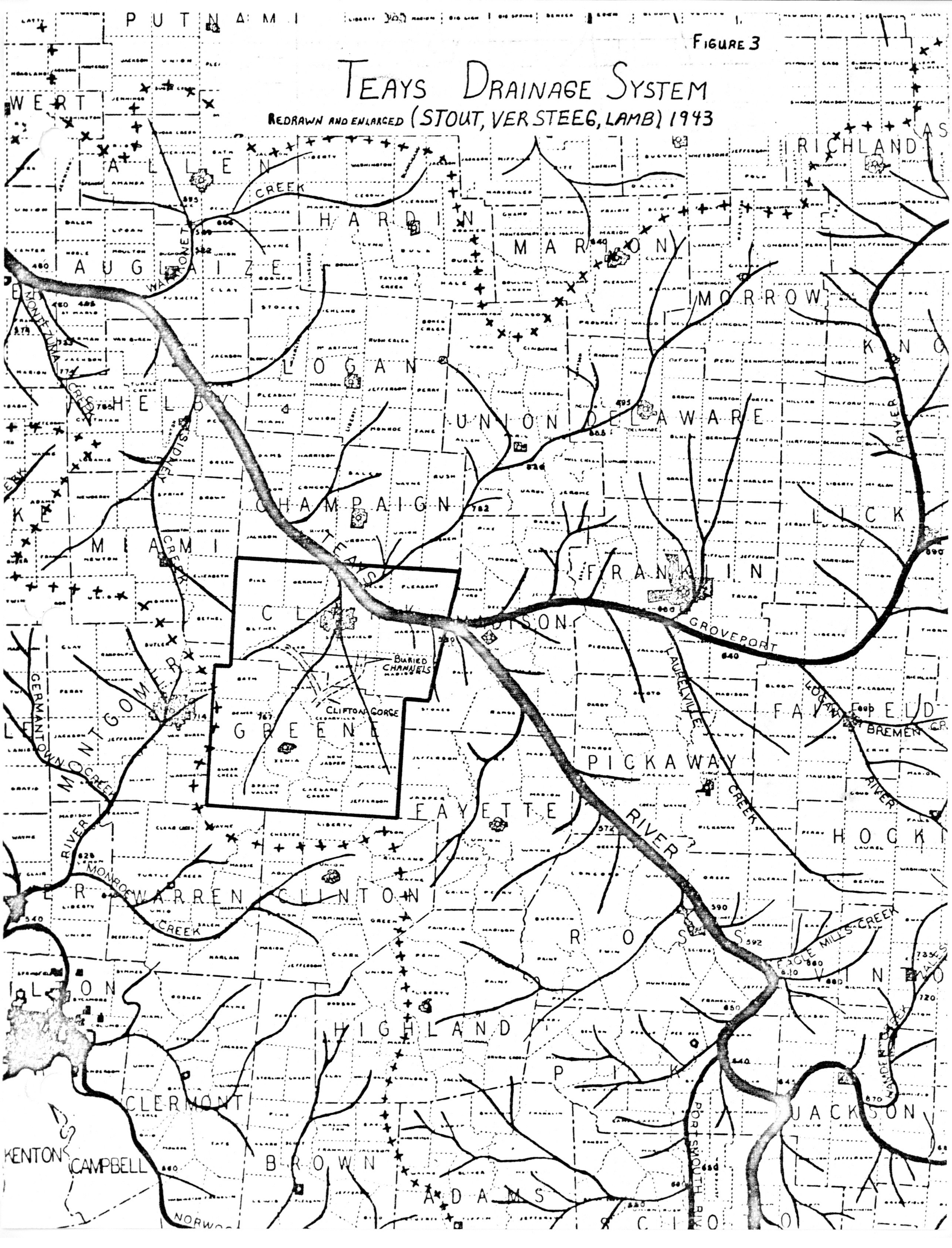
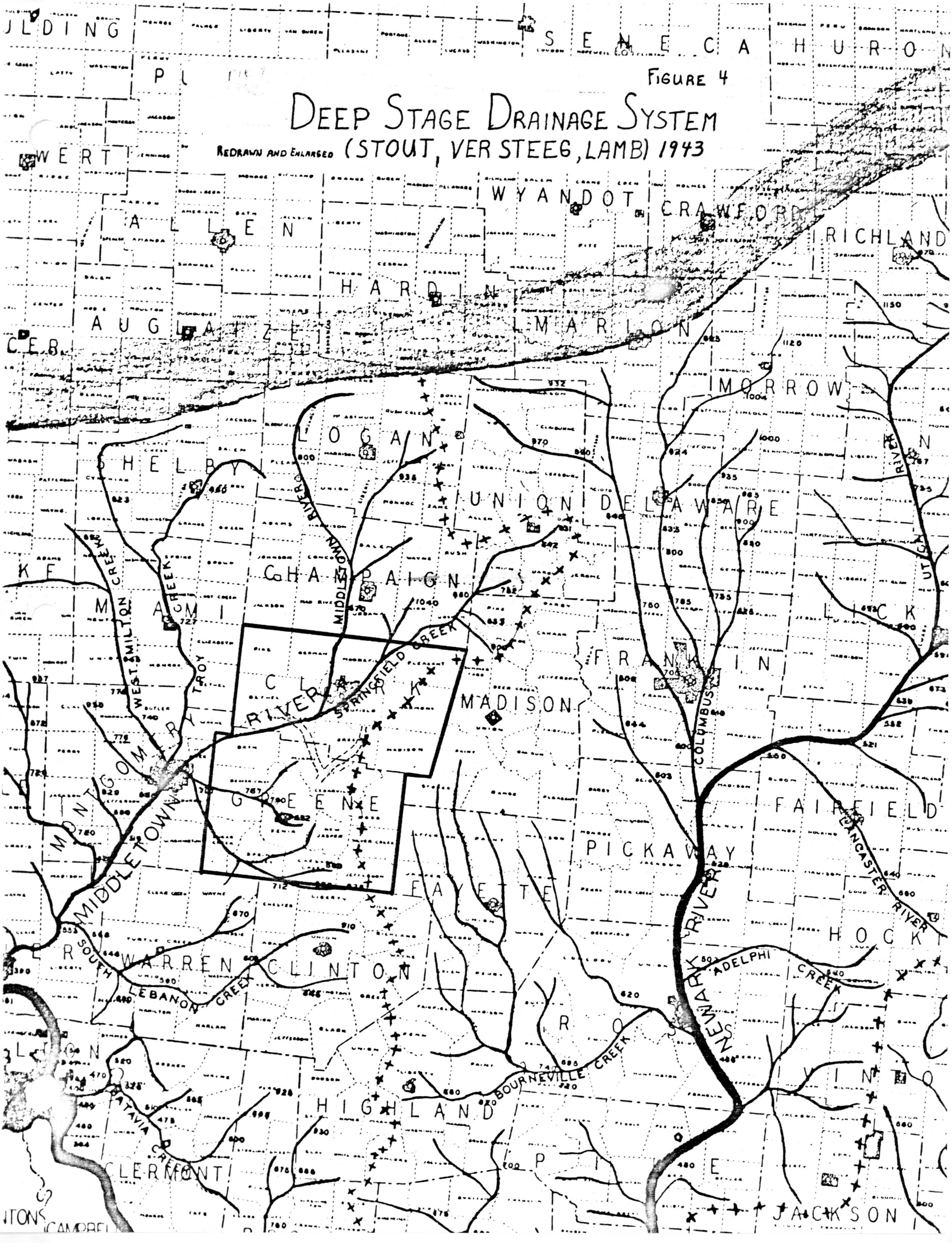
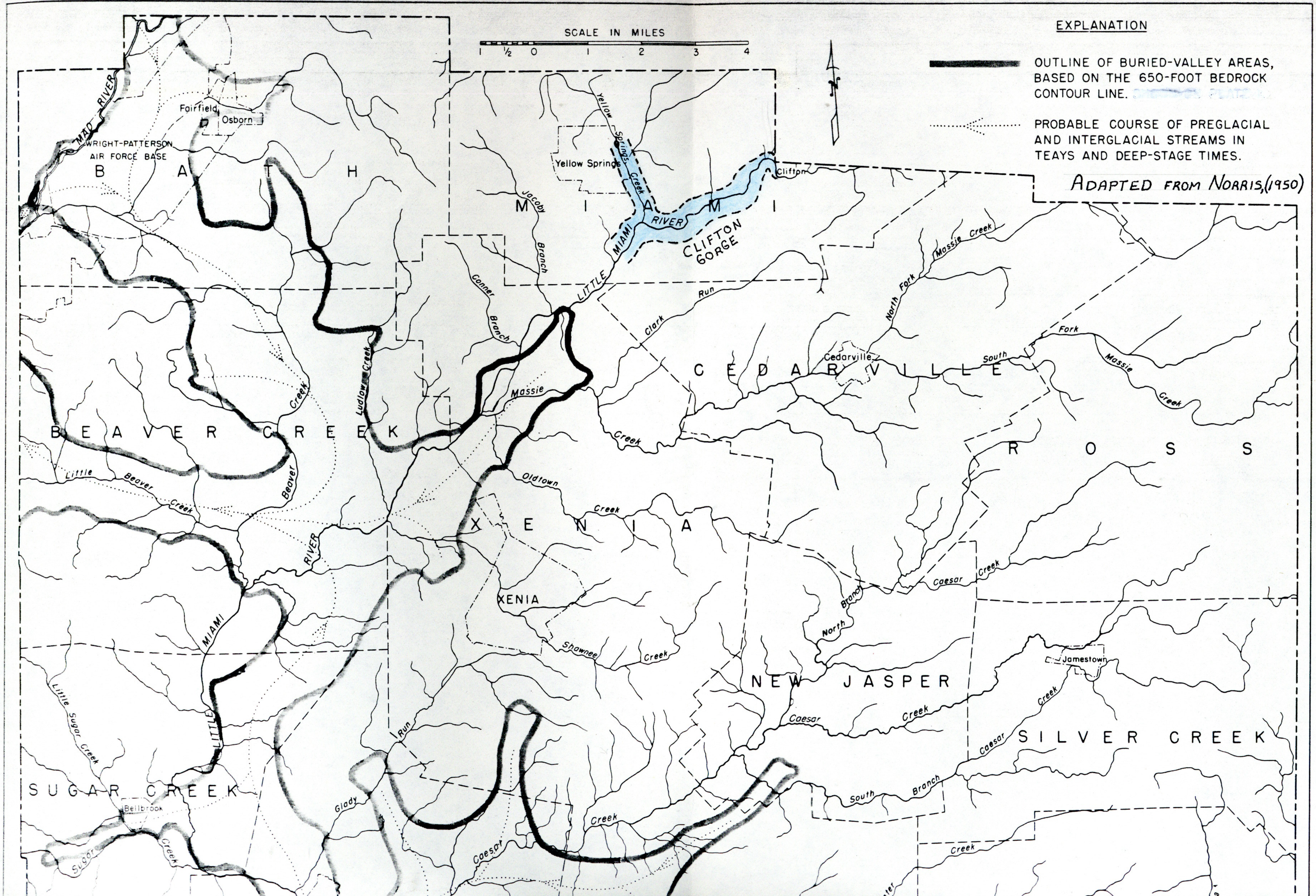


FIGURE 4

DEEP STAGE DRAINAGE SYSTEM

REDRAWN AND ENLARGED (STOUT, VER STEEG, LAMB) 1943



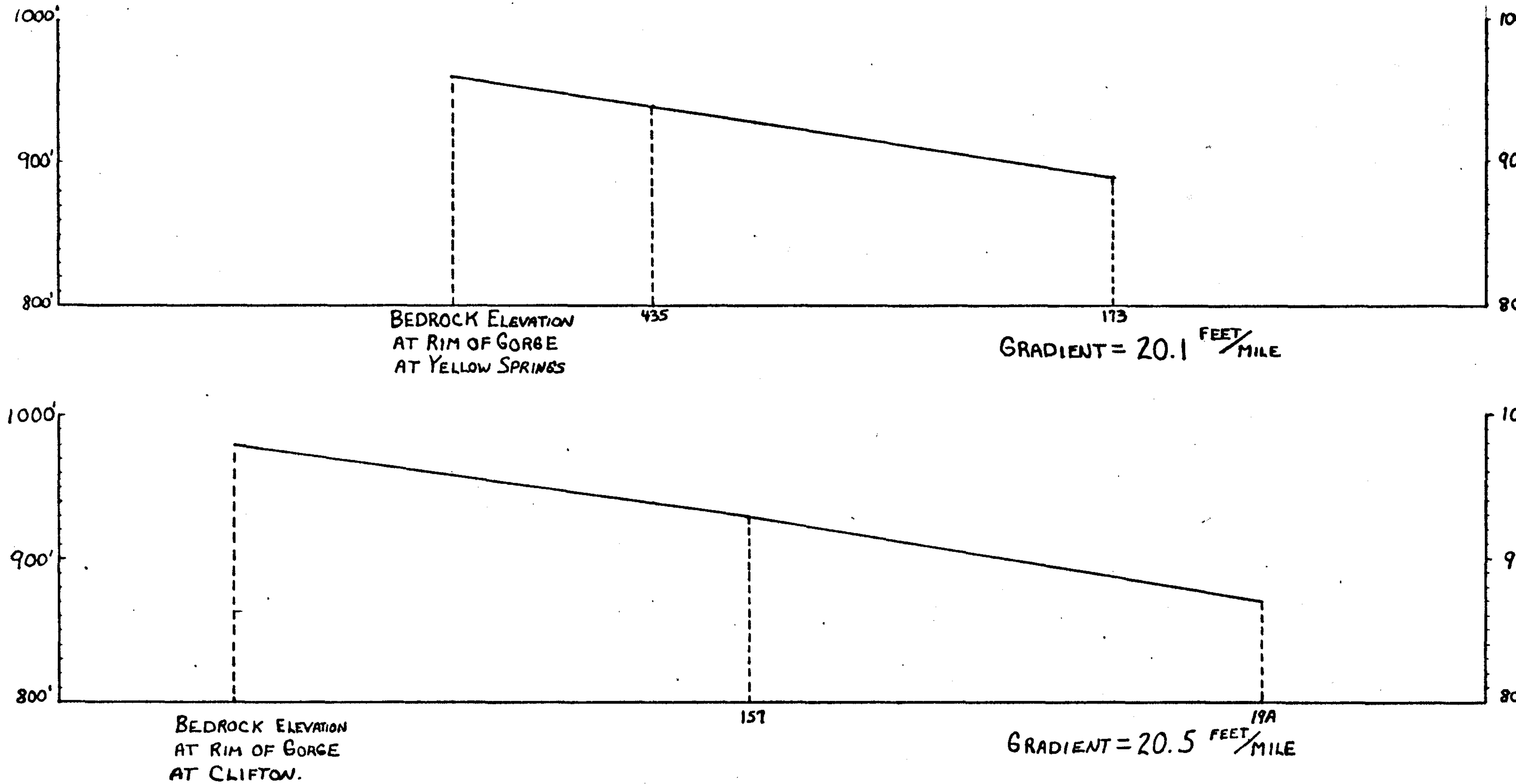

EXPLANATION
OUTLINE OF BURIED-VALLEY AREAS, BASED ON THE 650-FOOT BEDROCK CONTOUR LINE.
PROBABLE COURSE OF PREGLACIAL AND INTERGLACIAL STREAMS IN TEAYS AND DEEP-STAGE TIMES.
ADAPTED FROM NORRIS,(1950)
SCALE IN MILES
1 ½ 0 1 2 3 4
N
BATH
MIAMI
BEAVER CREEK
XENIA
CEDARVILLE
ROSS
NEW JASPER
SILVER CREEK
SUGAR CREEK
MAD RIVER
WRIGHT-PATTERSON AIR FORCE BASE
Fairfield
Osborn
Yellow Springs
Yellow Springs Creek
Clifton
CLIFTON GORGE
LITTLE MIAMI RIVER
Jacoby Branch
Conner Branch
Ludlow Creek
Massie Creek
Clark Run
North Fork Massie Creek
South Fork Massie Creek
Cedarville
Little Beaver Creek
Beaver Creek
Oldtown Creek
Shawnee Creek
XENIA
North Branch
Caesar Creek
Jamestown
South Branch
Glady Run
Little Sugar Creek
Sugar Creek
Bellbrook

mile of the line they are projected into. Considering the low surface relief of this area, any variations from the true surface and bedrock surface should be minimal. Furthermore, the large amount of information gained using this method of approximation overshadows the small inherent error in it.

Gradients (Figure 6) were constructed from points of maximum depth on cross sections. These points are located on a topographic sheet (Map in pocket), included in this report, and are connected by lines which approximate the buried channel's courses.

It should be noted that section AA' (Figure A) was not used in the construction of channel gradients. This is because its buried channel's depth was not as great as that of section FF', (Figure F), to the south. The approximate Yellow Springs Channel, therefore, does not pass through section AA' on the map (Map in pocket).

As a final note, a vertical exaggeration of 20 times was used on cross sections and 40 times on gradients. Such an exaggeration is large enough to accent prominent features of the bedrock surface while small enough to insure minor irregularities do not affect conclusions.



Approximate Buried Channel Gradients north of Yellow Springs (upper gradient) and north of Clifton (lower gradient).

Horizontal Scale 1" = 4000'.
Vertical Exaggeration of 40 X s, or, 1" = 100'.

Data for gradients is from those wells in the buried channels. Numbers of these wells are listed along the base of the gradients.

Figure 6

Pleistocene Glacial History of Clark and Greene Counties

The three glacial events which affected Clark and Northern Greene counties are the Kansan, or, some pre-Illinoian event, Illinoian, and Wisconsinan. The Kansan (?) ice sheet didn't actually reach these counties but did block the Teays River as it flowed northwest some 600,000 years ago, (Norris, Cross, Goldthwait, 1950, P. 11). This caused lakes to form in northwestern Ohio counties along the glacial front. Consequently, the normal load of the Teays system was added to the sediments derived from the glacier. These formed some of the early glacial outwash deposits of this event.

Ultimately the combined glacial and blocked Teays drainage initiated a new interglacial drainage system. This system, now known as the Deep Stage, profoundly affected drainage in Clark and Greene counties.

During the Illinoian glaciation, ice completely covered Clark and Greene counties as evidenced by Illinoian ground moraine at depth throughout the area, (Stout, 1943, P. 86), (Norris, and others, 1950, P. 11). During deglaciation, further changes in river systems and development of outwash deposits occurred.

The final glacial event was the Wisconsinan, which retreated from the area about 15,000 years ago, (Goldthwait, 1965). End moraines which formed along the glacial margin run through Greene County indicating the position of the glacial front in the county. This glacial advance came in the form of two lobes which were formed when the ice was impeded and split by a topographic high point in Logan County to the north. The Miami Lobe advanced from the northwest while the Scioto Lobe advanced from the northeast. (Figure 7).

WISCONSINAN ICE MARGIN
(STOUT, VER STEEG, LAMB) 1943
REDRAWN

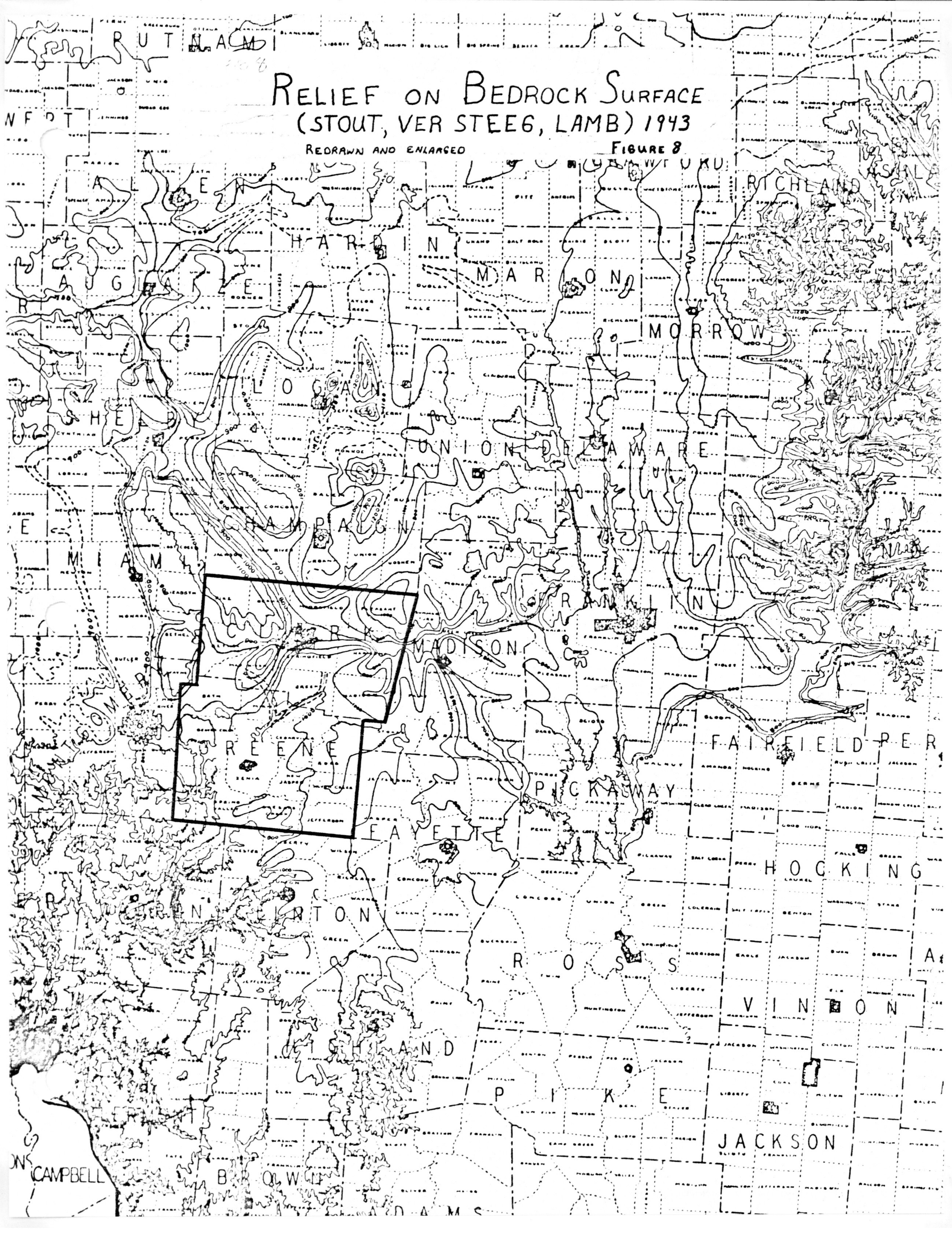
FIGURE 7

Drainage Changes

The Teays River which drained Ohio during pre-Kansan(?) time, flowed northwest through northern Clark County approximately 12 miles north of Clifton and Yellow Springs Gorges (Figure 3). The great depth of these gorges suggest that the channels through them began cutting at some time preceding the last glaciation, although rapid cutting of gorges can occur during deglaciation. Furthermore, if the gorges correlate with buried channels in the bedrock which extend north into the Teays Channel, the implication is that the gorges were cut by pre-glacial drainage to the north. One of the focuses of this report is exploring this possibility.

The definitive work on ancient drainage systems in this area was by Stout, Ver Steeg, and Lamb (1943). Their work serves as the framework and foundation for this study. This study defines abandoned tributary channels in the bedrock which are too small to be revealed by the mapping scale used in Stout's, Ver Steeg's, and Lamb's 1943 report (Figure 8).

Well logs were used in this report to construct



Relief on Bedrock Surface
(Stout, Ver Steeg, Lamb) 1943

Redrawn and enlarged

Figure 8

cross sectional and gradient profiles of the bedrock surface. The results indicate drainage was to the north through now buried bedrock channels which originate at the location of the present day gorges (Map in pocket).

Presumably these channels emptied into the Teays or a direct tributary of it. The gorges probably did not merge south of Yellow Springs as they do today because a Teays system drainage divide was located very close to the point of juncture (Figure 5). The two channels may have merged through headward erosion during Teays time. However, the depth of the gorge at this point (46 meters), suggest that the major downcutting took place during the following reverse drainage of the Deep Stage (Figures 4,5), or, perhaps even later.

Deep Stage silts and sands filled the Teays bedrock channel and its tributaries in Clark and Greene Counties. This erased the northward flowing dendritic Teays system in those counties (Brown, 1948, p. 5). The exception to this filling is a case of headward erosion through a divide in which a Hamilton River tributary extended northeast through Bath Township (Figure 4). The tributary joined with a formerly northward flowing Teays tributary (Figure 3). Its position is similar to that of the present day Mad River on the border of Mad River and Bethel Townships, Clark County. The incorporation of this section of channel extended the newly formed Middletown River (Figures 3,4), across Clark County.

Clifton and Yellow Springs Gorges were not major channels during the Deep Stage and it is questionable which direction flow was through Yellow Springs Gorge. This is because it ran parallel to the Middletown River into which the gorge had to eventually drain (Figure 4). Drainage direction through Yellow Springs Gorge would depend on the amount of Deep Stage silts and sands which clogged the channel's formet outlet to the north. With the great amount of silt and sand building up at the topographically low northern extension of the Yellow Springs channel, it is likely that the Deep Stage caused reverse of drainage from northward to southward.

Clifton Gorge, on the other hand, could only have had southerly drainage during the Deep Stage. A Deep Stage divide running northwest-southeast (Figure 4), cutoff the gorge's outlet to the north. Therefore, any drainage through the gorge had to be to the south.

Illinoian through Wisconsinan drainage continued the work of the Deep Stage on the gorges while it modified the southerly flowing Deep Stage System; compare Figure 4 to Figure5 .

Presently the Little Miami River flows through Clifton Gorge and drains Yellow Springs Gorge. The gradient of the Little Miami increases as it flows into Clifton Gorge at Clifton. Upstream the river flows over a post-Wisconsinan bed. Downstream, through the gorge, the river follows a section of a pre-Wisconsinan course.

Conclusions and Suggestion for Future Studies

Gradients of buried channels outlined on the included topographic sheet, (in pocket), defines the direction of the last major drainage through them. These directions are northwest for the Yellow Springs channel, and northeast but bending north for the Clifton channel.

While these buried channels lead into the gorges, the gradients in the gorges now run south. Therefore, a large amount of downcutting must have taken place in the gorges during subsequent drainage periods.

It is interesting that the values of the two buried channel gradients, (figure 6), are almost equal. It is possible that this value of 20 feet/mile, (3.8 meters/Km) is diagnostic of Teays System streams of this size.

Further studies might attempt to better define the course of these buried channels. This could be accomplished with consideration of data from recently drilled wells, or, with seismic data.

Another possibility for future study is to record the volume of water pumped out of wells in buried channel areas. These could then be compared to the average volume of water pumped per well in the entire area. This method would test the hypothesis that these buried channels are better than average sources of ground water.

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